BEST FIT PREDICTIONS FOR FLAVOUR VIOLATING PROCESSES IN MSSM CONSTRAINED BY UNIFICATION*

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We study the Minimal Supersymmetric Standard Model (MSSM) constrained by unification assuming mSUGRA SUSY breaking. In particular this means that the three gauge couplings are unified at a *per cent* level, third generation yukawa couplings are unified at a 10 % level, and at the unification scale $M_U \approx 10^{16}$ the SUSY breaking masses of squarks and sleptons are universal up to specific D-term contributions. At M_U we also include right-handed neutrinos that are decoupled at their three respective scales. In a top-down global analysis we then find that there are two distinct best fits, primarily distinguished by the masses of the non-Standard Model Higgs states, and compute the predictions for flavour violating processes involving both leptons and quarks. The fit with the light Higgs spectrum is especially interesting with regards to the decay $B_s \to \mu^+\mu^-$. We note that the latter results go beyond what is called minimal flavour violation in the MSSM.

Within the diversity of different approaches to the flavour problem a class of supersymmetric (SUSY) unification models can be recognised that is remarkably simple at the unification scale. This is the class of SO(10)-like models where the Standard Model (SM) gauge couplings unify to a per cent level, third family yukawa couplings are all of order unity, and the remaining flavour structure originates in a small set of higher-dimensional superpotential operators keeping the SUSY breaking sector flavour blind.

Here we report on flavour violation [1,2] in a Pati-Salam model which falls into this category. Our work is general and applies to any mSUGRA model with universal sfermion masses at M_U and a Higgs spectrum similar

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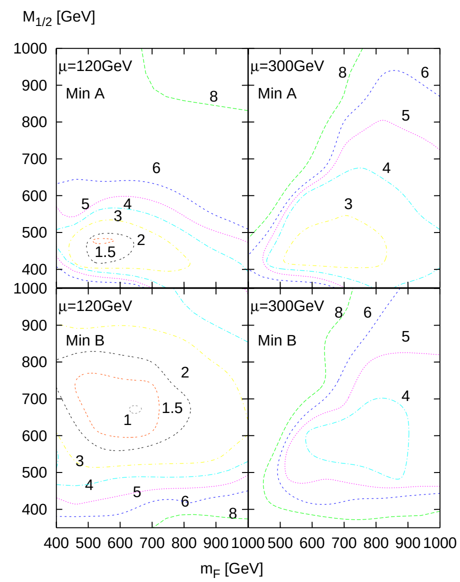

Figure 1. χ^2 contour plots in the plane of $(m_F, M_{1/2})$. The four plots are obtained from the two minima, Minimum A and Minimum B, with $\mu = 120$ and 300 GeV as labeled.

to the one considered here. In such a framework it is well known that, for a given choice of low energy fermion masses and CKM mixing angles, predictions on flavour violation in the quark sector are independent of the precise nature of the Yukawa matrices selected at high energy since different choices of Yukawa matrices can be rotated into each other. Apart from being general, our study contains a number of new features not present in previous works on flavour violating processes. One novel feature is to present results that are based on a top-down global analysis. In a top-down approach complete Yukawa and sfermion mass matrices are known at the low energy scale and no extra iteration (called resummation of large tanβ terms by some) is needed to extract the couplings which enter the evaluation of the SUSY loops. Another new aspect is a more complete analysis of the process $B_s \to \mu^+\mu^-$. The previous analyses of SO(10)-like models (see the list of references in Ref. 2) only considered minimal flavour violation with the rate $B_s \to \mu^+\mu^-$ explicitly proportional to the low-energy value V_{ts}^2 while our results are more general and include contributions from additional diagrams. Such contributions, which arise from inter-generational squark mixing effects, have so far been ignored in mSUGRA based analyses.

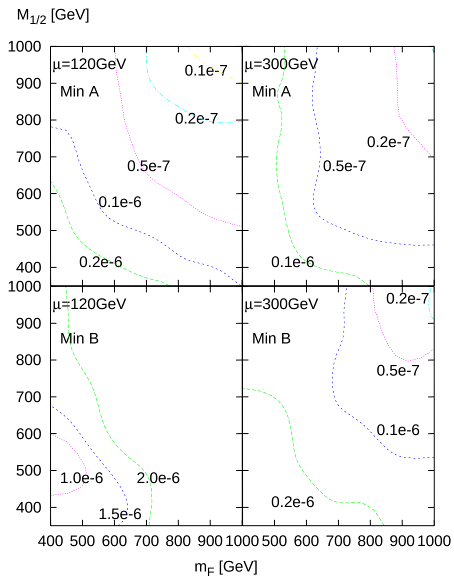

Figure 2. Contours of $BR(\tau \to \mu\gamma)$ plotted in the plane of $(m_F, M_{1/2})$. The four plots, are obtained from the two minima, Minimum A and Minimum B with $\mu = 120$ and 300 GeV as labeled.

In our top-down numerical analysis we vary the following gauge and SUSY parameters at the unification scale: $M_U,\ \alpha_U,\ \epsilon_3 \equiv (\alpha_3 - \alpha_U)/\alpha_U$, $m_F^2 \equiv m_0^2,\ M_{1/2},\ m_h^2$ and D^2. $A_0(M_U) = 0$ and $\tan\beta(M_{top}) = 50$ are kept fixed while $\mu(M_{top})$ can be controlled. We also vary parameters of order unity that enter the hierarchical yukawa and right-handed neutrino matrices at scale M_U. At low scale the one-loop effective potential is minimised and with the obtained Higgs *vev*'s the χ^2 is computed based on the fit of 24 observables. The latter include the gauge couplings, fermion masses and mixings and vector boson masses. We emphasise that the 32 flavour mixing is restricted by observables V_{cb}, [3] $U_{\mu 3}$, and the $BR(b \to s\gamma)$. Finally, constraints on unobserved sparticle masses are imposed.

Two distinct minima, Minimum A and Minimum B, are found (see Figure 1). They both predict $m_h \approx 115\,\mathrm{GeV}$ [4] and a low value for $\mu(M_{top})$ giving light higgsino-like chargino and neutralino. The difference is the light (heavy) Higgs sector in Minimum A (Minimum B) and heavier (lighter) slepton masses in Minimum A (Minimum B) — see Figures 10 and 3 in the second reference 1. The latter result leads to a significant prediction for the lepton flavour violating $\tau \to \mu\gamma$ decay, Figure 2, at the present

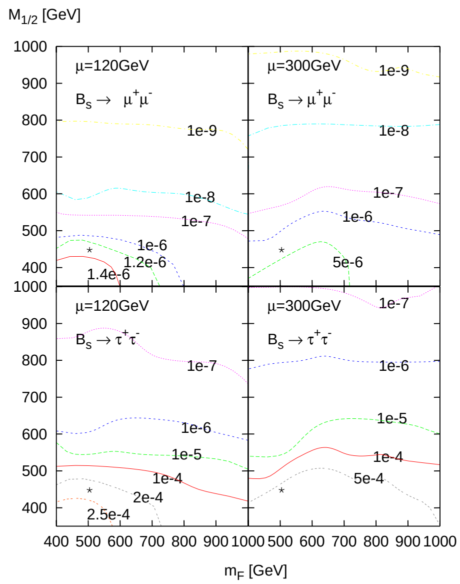

Figure 3. Contour plots for the branching ratios of the FCNC processes, $B_s \to \mu^+\mu^-$ and $B_s \to \tau^+\tau^-$ in Minimum A. Each branching ratio is plotted with two different values of the μ parameter. The $\star$ marks the Minimum A best fit point.

limit (Minimum B) or within the reach of the B factories in the near future (Minimum A). More importantly, the light pseudoscalar Higgs in Minimum A leads to the exciting prediction for Higgs mediated pure leptonic $B_s \to \mu^+\mu^-$ decay (the two upper panels in Figure 3). Sensitivity to $BR(B_s \to \mu^+\mu^-) \approx 10^{-7}$ at the Tevatron would be very restrictive and could probe $m_{A^0} \lessapprox 300\,\mathrm{GeV}$, a truly remarkable result. We repeat that it has been derived based on the full computation in generation space that goes beyond the minimal flavour violation. In Minimum B, $B_s \to \mu^+\mu^-$ is not enhanced over the small SM rate due to the much heavier Higgs spectrum.

References

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